# SECTION 9 - UPPER ABDOMEN ASSEMBLY

## 9.1 Upper Abdomen Assembly Description and Features

The upper abdomen is the region on the dummy that represents the lower thoracic cavity. Physically, this component fills the volume that exists between the lowest three ribs, above the lower abdomen and in front of the spine. The component is primarily constructed of deformable materials to produce a compression response similar to human cadaver test data. Instrumentation is incorporated into the component to measure the impact penetration and acceleration. A drawing of the complete upper abdominal assembly is provided in **Figure 9.1**.

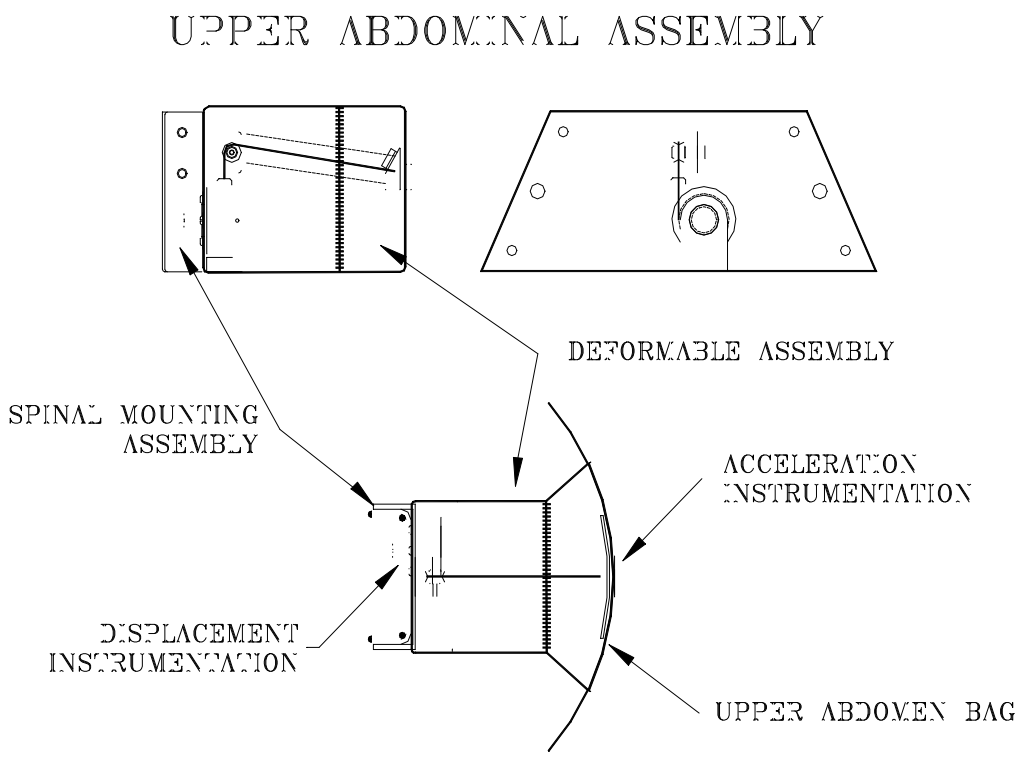


**Figure 9.1-** Upper abdomen assembly

The upper abdomen assembly consists of a Cordura nylon bag that encloses a series of layered foams. Cordura is a very durable fabric and the seams of the bag are sewn with Kevlar thread to prevent tearing. Two flaps extend laterally from the front surface of the upper abdomen to allow it to be bolted to the ribs and bib layers. A zipper provides access to the interior of the bag to inspect the foams and instrumentation. There are two different layers of foam that are used to obtain the proper compression response. Each layer has a hole cut through it to allow the string transducer cable to pass through to the front cover.

There are two types of instrumentation installed into the upper abdomen. A string transducer is installed to measure the abdominal penetration in the X-axis of the dummy's coordinate system. The string transducer is mounted on the forward surface of the internal mounting plate with the cable passing through the foams to the front surface of the fabric where it is connected. The second sensor is a uniaxial accelerometer that is mounted onto a Delrin block on the front surface of the bag assembly. The mounting surface has been cut to roughly direct the active axis of the accelerometer in the -X direction. This sensor measures the acceleration generated during impacts by objects, such as an airbag or a loose shoulder belt slapping against the upper abdomen of the dummy.

## 9.2 Upper Abdomen Assembly

### 9.2.1 Parts List

The parts list and all quantities for the upper abdomen assembly are listed in Appendix I - Bill of Materials under the Upper Abdomen subsection. Refer to drawing T1UAM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 9.2** is a photograph of the exploded upper abdomen assembly and hardware.

**Figure 9.2-** Exploded upper abdomen assembly

### 9.2.2 Assembling the Upper Abdomen Components

The following procedure is a step-by-step description of the assembling all upper abdomen components. The numbers noted in ( ) refer to a specific drawing / part number for each particular part. The numbers noted in the { } indicate the hex wrench size required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values.

1. Bolt the Pulley Wheel Assembly (T1UAM210, T1UAM211, T1UAM212) to the forward facing surface of the Internal Mounting Plate (T1UAM252) using four #6-32 x 3/8" FHSCS {5/64}, as shown in **Figure 9.3**. (Note: The forward facing surface is on the same side, opposite the flanges.)

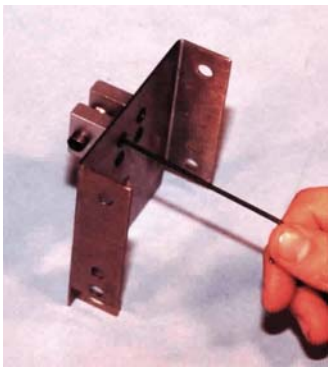

**Figure 9.3-** Pulley wheel assembled to internal plate assembly

2. Fit the cylindrical protrusion of the string transducer through the hole of the String Potentiometer Mounting Bracket (T1UAM213). Orient the bracket so the body of the string potentiometer is nestled in the "L" of the bracket. Rotate the string transducer so the string is pointed in a direction that is away from the end containing the three mounting holes. Tighten the two #4-40 x 3/8" SSS {0.050} on each side of the holder just enough so the string transducer cannot be removed, but still may be rotated within the holder. This is shown in **Figure 9.4**.

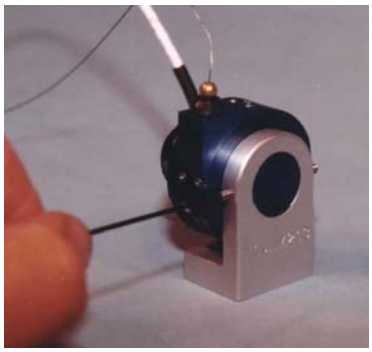

**Figure 9.4-** String potentiometer in mounting bracket

3. Bolt the string potentiometer mounting bracket to the same surface as the pulley wheel assembly using three #6-32 x 3/8" FHSCS {5/64}. The rotary potentiometer should protrude through the "clover-shaped" hole of the internal mounting bracket.

4. Rotate the string transducer in its holder to allow the string transducer cable to pass from the black Delrin cable guide on the string transducer housing to the pulley wheel with minimal resistance. Proper alignment of the string potentiometer is shown in **Figure 9.6**. (Note: The adjustment allows tangential motion of the cable off the drum.)

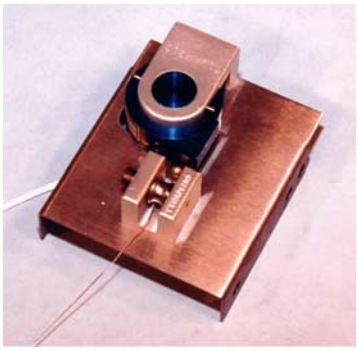

**Figure 9.5-** Proper alignment of string potentiometer

5. Pass the string transducer cable underneath the center of the pulley wheel.

6. Align the Internal Foam Rear Layer (T1UAM010) to match the positions of the string transducer and pulley wheel assembly. Push it into place around the potentiometer, as shown in **Figure 9.6**.

**Figure 9.6-** Internal foam rear layer installed

7. Pass the electrical cable for the string transducer through the “clover-shaped” hole in the rear of the Bag Assembly (T1UAF300) from the inside to the outside, until it is possible to insert the entire assembly into the rear of the bag. Ensure that the holes in the bag and the flanges of the bracket are properly aligned. Proper assembly of the fabric bag to the mounting plate is shown in **Figure 9.7**.

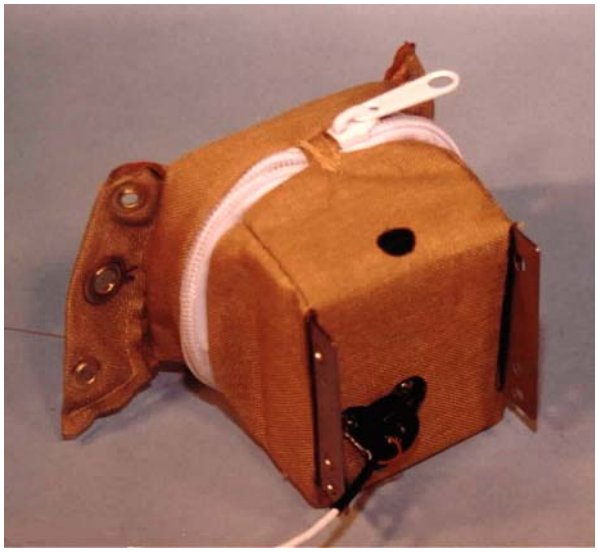

**Figure 9.7-** Bag assembled to mounting plate

8. Thread the string transducer cable through the hole in the Internal Foam Middle Layer (T1UAM011). Insert this middle layer of foam into the bag as shown in **Figure 9.9**.

**Figure 9.8-** Middle foam layer in bag

9. Thread the string transducer cable through the hole in the Internal Foam Front Layer (T1UAM012). Insert this front layer of the foam into the bag.

10. The upper abdomen can be instrumented with a uniaxial accelerometer (T1INM110) to measure the acceleration of the bag face during impact. Mount the uniaxial accelerometer to the Accelerometer Mount (T1UAM015) using two #0-80 x 1/4" SHCS {0.050} and two #0 washers as shown in **Figure 9.9**. The electrical cable from the uniaxial accelerometer unit should be oriented toward the narrow end of the accelerometer mount wedge.

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**WARNING:** Do not over tighten the #0-80 bolts. A snug fit is adequate to secure the sensor. Over tightening may cause damage to the accelerometer!!!

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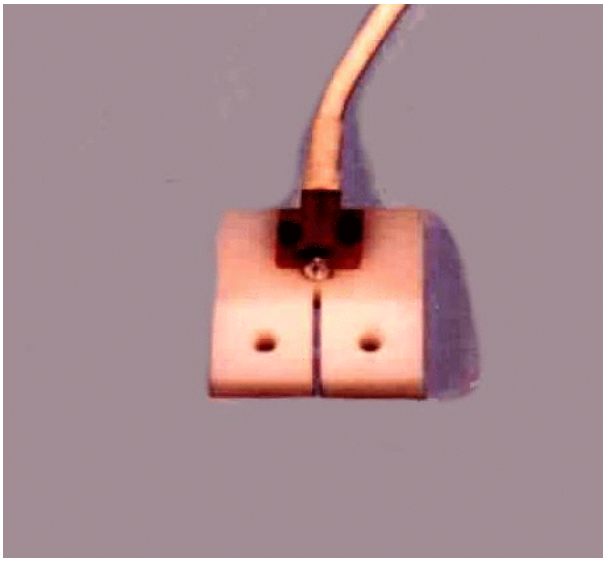

**Figure 9.9-** Uniaxial accelerometer on accelerometer mount

11. Thread the accelerometer's electrical cable above the foam layers in the bag assembly and through the small hole at the top rear of the bag from the inside to the outside, as shown in **Fig 9.10**.

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**NOTE:** The hole bored in the foam layers for the string potentiometer cable is angled to direct the cable from the top of the bag at the rear to the middle of the bag at the front face.

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**Figure 9.10-** Accelerometer wire routing

12. Pull the string potentiometer cable through the foams using a pair of pliers until the swag ball appears.

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**WARNING:** Be very careful not to pull the string further than one inch from the surface of the grey polyester foam. Extending the string any further may cause damage to the string transducer!!!

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13. Position the accelerometer mount at the front of the internal foam front layer and slide the slot of the accelerometer mounting block over the cable, with the swag ball socket facing the swag ball, as shown in **Figure 9.11**. Allow the string to retract with the ball seating into the ball socket. Slowly release the cable and allow the accelerometer mounting block to rest against the front foam layer. The uniaxial accelerometer is positioned directly against the front foam layer.

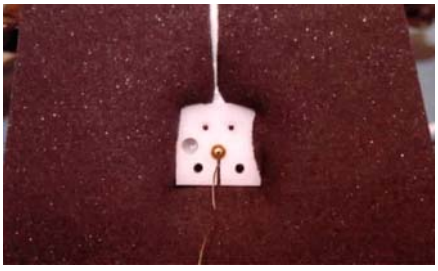

**Figure 9.11-** Cable inserted on accelerometer block

14. Place two #4-40 x ½" FHSCS {1/16} through the holes in the String / Accelerometer Mount Plate (T1UAM014). Align the bolts with the holes on the front of the upper abdomen bag and push the bolts through the holes. The plate should be oriented with the 1/4" diameter through hole at the upper right side, as shown in **Figure 9.12**.

**Figure 9.12-** String potentiometer / accelerometer mounting plate

15. Position the Load Distribution Plate (T1UAM013) on the inside front surface of the upper abdomen bag and push the holes of the plate onto the protruding bolts from Step 14, as shown in **Figure 9.13**.

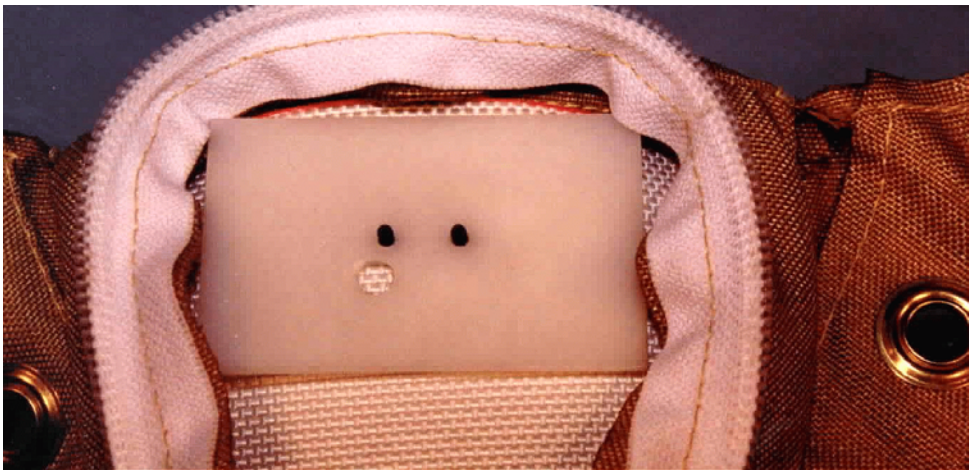

**Figure 9.13-** Load Distribution Plate inside of bag

16. Align the bolts with the threaded holes in the accelerometer mount and thread the #4-40 bolts from the front plate into the corresponding threaded hole of the mounting block.

17. Position the foam layers into the bag and zip the bag assembly closed.

18. Pass the accelerometer cable underneath the Velcro stay on the top surface of the bag. The bag assembly is shown in **Figure 9.14**.

**Figure 9.14-** Accelerometer cable beneath the velcro stay

19. Pass the instrument wire from the string potentiometer through the ½" diameter hole in the lower left side of the Spine Mounting Bracket Assembly (T1UAM100). Position the bag assembly into place over the Spine Mounting Bracket Assembly as shown in **Figure 9.15**. Secure the string potentiometer wire to the spine mounting bracket using a zip-tie.

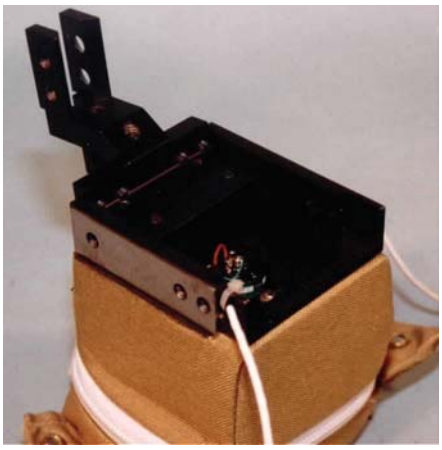

**Figure 9.15-** Bag attached to mounting bracket

20. Install the upper and lower CRUX units to the upper abdomen assembly as described in Section 16 - CRUX Units. Secure the CRUX wires to the upper abdomen assembly with a 1/4-20 x ½" BHSCS {5/32} and a 1/4" nylon cable clamp on each side. These bolts are fastened through the top mounting hole of the Upper Abdomen assembly.

### 9.2.3 Installing the Upper Abdomen into THOR

The following procedure is a step-by-step description of the assembly procedure used to attach the upper abdomen to the completed thorax assembly. The numbers provided in ( ) refer to a specific drawing / part number of each part. The numbers noted in { } after the bolt size indicate the hex wrench size required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values. The upper abdomen can be installed either before or after the thorax assembly is complete. This procedure assumes that the spine of the dummy with the ribs and bib is already assembled, and that ribs #5, 6, and 7 are not attached to the bibs.

1. Check the adjustment of the string potentiometer as described in Section 9.5

2. Loosen the center bolt of the lower thoracic spine pitch change mechanism as described in Section 6.3.1. Rotate the upper thorax and spine rearwards to open the thoracic cavity and allow easy access. This will provide space between the upper and lower abdomen assemblies.

3. Position the spinal mounting bracket arms on either side of the lower thoracic spine weldment and carefully slide the upper abdomen / CRUX assembly into the dummy's thorax.

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**WARNING:** It is very easy to pinch the wire from the lts tilt sensor during the installation of the upper abdomen. This wire is routed between the arms of the upper abdomen spine mounting bracket.

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4. Align the holes and fasten the spinal mounting bracket to the lower thoracic spine weldment using two 5/16-18 x 1" FHSCS {3/16} into the two mounting holes in the spinal mounting bracket arms from the right side, as shown in **Figure 9.16**.

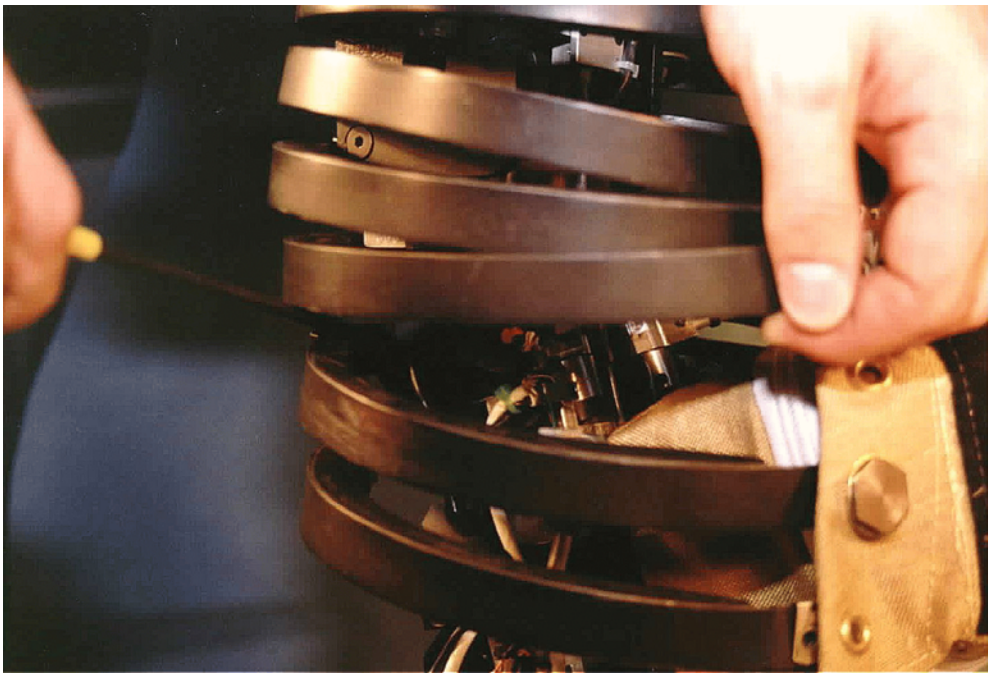

**Figure 9.16-** Upper abdomen mounting to spine

5. Insert the U-joint of each lower CRUX unit through the 3/8" holes of rib #6. Then pass the U-joint through the 3/8" grommet of the upper abdomen flaps. Push the separate layers of the bib over the end of the U-joint. Screw the rib connecting bolt into the U-joint to secure the CRUX units, upper abdomen, and bib layers together. For additional details, refer to Section 7 - Thorax Assembly.

6. Pass the mid-sternum accelerometer wire under the velcro tab on the top of the upper abdomen bag and route this wire with the upper abdomen uniaxial accelerometer wire.

7. Readjust the lower thoracic pitch change mechanism to the desired setting as described in Section 6.3.1, Adjustment Procedure for Lower Thoracic Spine Pitch Change Mechanism.

8. After the installation of the lower abdomen is complete, cover the front surfaces of the upper and lower abdomen assemblies with the Upper and Lower Abdomen Velcro Cover (T1LAF117), as shown in **Figure 9.17**

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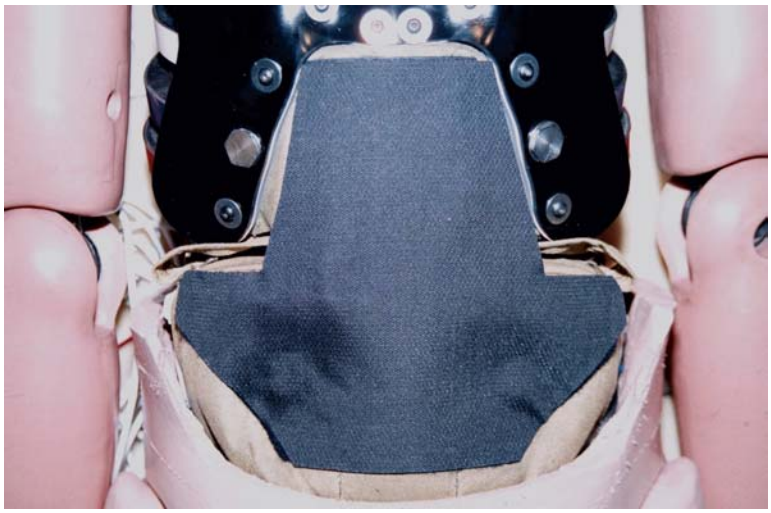

**Figure 9.17-** Proper location of Upper and Lower Abdomen cover

## 9.3 Adjusting the Upper Abdomen Assembly

Except for the initial adjustment of the rotary potentiometer as described in Section 9.5, the upper abdomen assembly does not require further adjustments for testing.

### 9.3.1 Storage and Handling

Storage of the upper abdomen unit can greatly effect the longevity of the unit. Due to the nature of the string potentiometer, the upper abdomen is subjected to a constant compressive loading. Over time, during storage and shipment, loading can cause permanent compression of the upper abdomen foam. Damage can be avoided by using one of the following procedures:

1) Release the string potentiometer cable from the accelerometer mount at the front of the upper abdomen bag and allow the cable to retract slowly into the bag. This will remove the cable tension from the assembly, but reattachment of the cable must be done prior to further testing.

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**WARNING**: The string potentiometer cable will snap if the cable is allowed to retract quickly into the housing. The cable must be lowered under tension very slowly during the disassembly.

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or 2) Using the abdomen storage fixture will relieve the tension placed on the foam by the string potentiometer. The Abdomen Storage Fixture (T1FDT210) is an optional item and may be ordered from GESAC. Instructions on how to use the abdomen storage fixture are located in Section 2.8- Abdomen Storage Fixture.

## 9.4 Electrical Connections and Requirements

The upper abdomen has two primary instruments: the string potentiometer and the uniaxial accelerometer. In addition, the four CRUX units are attached to the upper abdomen prior to installation within the dummy. Finally, the instrument wire from the mid-sternum uniaxial accelerometer is routed with the upper abdomen instrumentation.

String Potentiometer Wire: This wire exits the string potentiometer from the rear of the upper abdomen bag assembly. The wire is passed through the lower left side of the spine mounting bracket assembly and secured using a zip-tie. This wire is then routed directly to the wire bundle running down the back of the spine.

Upper Abdomen Uniaxial Accelerometer: This wire is routed through the upper abdomen bag and is secured to the top of the bag with a strip of Velcro. The wire from the mid-sternum uniaxial accelerometer is bundled with this wire and secured to the same Velcro strip. These wires are then routed to the left of the spine and secured to the same wire clamp as the left-side CRUX units. Finally, the wires exit the thorax to join other wires running down the spine.

CRUX Units - Routing of the wires from the CRUX units is discussed in Section 16-CRUX units. The wires from the upper and lower CRUX units are strain-relieved with a wire clamp attached to each side of the Upper Abdomen Spine Mount (T1UAM100) with a 1/4-20 x ½" BHSCS {5/32}. The wires are then routed on the left and right sides of the spine assembly and exit the thorax below rib #7 to join the bundle of wires running down the dummy's spine.

Mid-Sternum Uniaxial Accelerometer: Bundle the instrument wire from the mid-sternal uniaxial accelerometer with the upper abdomen uniaxial accelerometer wire. Pass the wires around the left side of the spine and secure them into the wire clamp, located on the upper abdomen assembly, used to fasten the upper and lower left CRUX wires. The cables are routed out the left side of the dummy to join the bundle of cables running down the spine.

## 9.5 Upper Abdomen Certification

The upper abdomen assembly certification is a dynamic impact test. This test is conducted with a steering-wheel shaped impactor. The results of the dynamic testing, produce a graph of impact force versus internal deflection measured by the string potentiometer unit. Certification procedures for this test are described in the THOR Certification Manual - available from the manufacturer as a separate publication.

### 9.5.1 Calibrating the String Potentiometer

The string transducer requires adjustment to properly set the initial position of the rotary potentiometer. This adjustment will produce a nearly zero voltage for the uncompressed condition of the abdomen. Measurements of the deflection are made from this starting point. This initial calibration was performed at the manufacturer during dummy assembly. Use the following procedure if the string potentiometer does not appear to be correctly calibrated.

1. Connect the sensor to a power supply and voltage meter as described in Section 15 - Instrumentation and Wiring. Power the sensor with 10 V DC and less than 100 mA.

2. Measure the initial output voltage of the uncompressed upper abdomen. The value should fall in a range between 0.000 and 0.020 $mV/V_{EX}$. If the uncompressed voltage falls within that range, the potentiometer is adjusted properly; do not proceed. If the value is outside the above range, continue with Steps 3 through 7.

3. Loosen the three slotted screws around the rotary potentiometer of the string transducer. They are accessible through the "clover-shaped" hole in the rear of the abdominal bag.

4. Rotate the rotary potentiometer a small amount. Measure the output voltage. If the output voltage is closer to the desired range, continue rotating the potentiometer in the same direction. If the voltage has changed further from the range, rotate the potentiometer the opposite direction.

5. Repeat step #4 until the initial voltage is within the desired range.

6. Tighten the screws around the rotary potentiometer.

7. Measure the output voltage to ensure that the initial voltage did not change when the screws were tightened. If the initial value has fallen outside the range, repeat Steps 3 through 7.

## 9.6 Inspection and Repairs

After a test series has been performed, there are several inspections that ensure the integrity of the dummy has remained intact. Good engineering judgement should be used to determine the frequency of these inspections; however the manufacturer recommends a thorough inspection after twenty tests have been performed. Inspection frequency should increase if the tests are particularly severe, or unusual data signals are being recorded. Both electrical and mechanical inspections should be performed. These inspections are most easily carried out during dummy disassembly. Disassembly of the upper abdomen components can be performed by simply reversing the assembly procedure.

### 9.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all instrument wires

from the upper abdomen instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections that would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure they are properly strain-relieved. A more detailed check on the individual instruments is covered in Section 15 - Instrumentation and Wiring.

**9.6.2 Mechanical Inspection**

Several components in the upper abdomen assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below. Please contact the manufacturer regarding questions about parts that fail the mechanical inspection.

Bag and Zipper Inspection: The following checklist should be used when inspecting the upper abdomen bag and zipper for post-test damage:

- Check the bag for tears, cuts and broken stitches. Repair or replace as necessary

Foam Inspection: The following checklist should be used when inspecting the upper abdomen foam for post-test damage:

- Check the foam for tearing and rips
- Check the foam for permanent compression caused by cable tension in the string potentiometer. Permanent compression can be eliminated through careful storage and handling, as described in Section 9.3.1- Storage and Handling